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The Effect of Cancer and Its Management on Orthodontic Treatment Outcomes: Systematic Review

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Abstract

Orthodontic treatment for patients undergoing cancer therapy presents unique challenges due to the effects of chemotherapy and radiotherapy on oral health. The impact of oncological treatments on orthodontic outcomes, including dental development, malocclusions, and treatment success, remains an area of ongoing research. This systematic review aim to evaluate the influence of radiotherapy and anti-neoplastic drugs on the successful completion of orthodontic treatment plans.A comprehensive literature search was conducted across six databases following PRISMA guidelines. The PICOS framework guided the study selection, focusing on individuals with dental or occlusal issues undergoing or recovering from cancer treatment. Eligible studies included retrospective, case-control, prospective case-control, and cross-sectional designs. The review included studies from various regions with diverse sample sizes. Findings indicated that 60% of children receiving chemotherapy achieved successful orthodontic outcomes, though chemotherapy significantly reduced treatment efficacy for certain malocclusions. Radiation therapy was associated with an increased risk of root resorption and microdontia compared to chemotherapy. Cancer treatments significantly influence orthodontic treatment success, with chemotherapy and radiotherapy impacting dental outcomes in distinct ways. While orthodontic treatment remains viable for cancer patients, individualized planning and multidisciplinary collaboration are crucial to optimizing results. Future research should focus on larger prospective studies to refine treatment guidelines and address confounding factors affecting orthodontic outcomes in oncological patients.

Introduction

Orthodontists play a vital role in addressing dental and occlusal concerns in patients with systemic diseases, ensuring a well-coordinated and holistic approach to care [1]. Their expertise extends beyond correcting malocclusions and misaligned teeth, as they collaborate closely with other healthcare professionals to integrate orthodontic treatment into the broader medical management of these patients [2]. The initial step in this process involves a comprehensive evaluation of the patient's occlusion, tooth alignment, and jaw relationships to identify specific orthodontic needs [3]. By thoroughly assessing the dental and facial structures, orthodontists develop customized treatment plans that aim to enhance functionality, aesthetics, and overall oral health [4]. Additionally, when dealing with individuals with systemic conditions, orthodontists work alongside primary care providers, specialists, and multidisciplinary medical teams to ensure that dental treatments complement the patient's overall health management [5]. This collaboration facilitates a thorough understanding of the patient's medical background and enables the orthodontic care

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plan to be safely and effectively integrated into their general treatment strategy [6]. Furthermore, orthodontists must take into account how systemic conditions and their treatments influence oral health [7]. Diseases such as diabetes, cardiovascular issues, and autoimmune disorders can contribute to complications like gum disease, tooth mobility, and alterations in bone density, which can significantly impact orthodontic outcomes [7].

Among systemic diseases, cancer has a particularly profound effect on oral and dental health across different age groups [8]. The consequences of cancer, including its treatment modalities, vary based on factors such as cancer type, progression stage, and individual patient characteristics [9]. In pediatric and adolescent patients, cancer and its therapies can disrupt normal dental development, potentially delaying tooth eruption or causing abnormalities in tooth structure [10]. Additionally, chemotherapy and radiation therapy administered at a young age may interfere with enamel formation, leading to enamel hypoplasia and an increased risk of dental caries [11]. In adults, cancer treatments often contribute to complications such as xerostomia, oral mucositis, and jaw osteonecrosis, largely due to the medications prescribed during therapy [12]. Moreover, anti-cancer treatments can weaken the immune system, heightening the risk of oral infections, including fungal infections such as oral thrush or viral conditions like herpes simplex virus [12].

Despite the growing body of research on the interplay between orthodontic care and anti-cancer treatments, several gaps remain that warrant further investigation [13,14]. One of the most pressing concerns is the absence of standardized protocols for managing orthodontic treatment in patients undergoing cancer therapy. Without uniform guidelines, it becomes difficult to compare outcomes across different studies and establish evidence-based best practices. Developing standardized treatment protocols would help create consistency in orthodontic approaches and improve the evaluation of treatment effectiveness. Additionally, the small sample sizes and limited demographic diversity in existing studies pose challenges in drawing generalizable conclusions. The lack of consensus on measurable treatment outcomes further complicates the ability to compare findings across research studies and conduct meaningful . Establishing standardized outcome measures would enable better data synthesis and provide a more robust understanding of the implications of cancer treatments on orthodontic care. Therefore, this systematic review aim to consolidate and evaluate the available evidence on how radiotherapy and anti-neoplastic drugs affect the successful completion of orthodontic treatment plans.

Materials and Methods

- This systematic review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological rigor in study selection, data extraction, and analysis [15,16].A structured approach using the PICOS framework (Population, Intervention, Comparison, Outcome, Study Design) was implemented

A systematic literature search was conducted across six major online databases, employing Medical Subject Headings (MeSH) and Boolean operators for a comprehensive query. The search strategy involved identifying key concepts: (1) Cancer (e.g., "neoplasms," "leukemia," "lymphoma"), (2) Orthodontic Treatment (e.g., "orthodontics," "dental occlusion"), and (3) Treatment Success (e.g., "treatment outcome," "treatment efficacy").

To ensure the inclusion of relevant and high-quality studies, predefined eligibility criteria were established.

Inclusion Criteria:

- Primary research studies, including randomized controlled trials (RCTs), cohort, case-control, and cross-sectional studies.
- Studies involving cancer patients of any age who underwent orthodontic treatment.
- Investigations assessing the impact of cancer therapy on orthodontic outcomes.

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- Studies with a control or comparison group (e.g., healthy individuals or cancer patients with different treatment protocols).

- Measurable treatment success indicators, such as dental occlusion, malocclusion classification, and other orthodontic outcome parameters.

Exclusion Criteria

- Non-primary research (e.g., review articles, case reports).

- Animal studies.

- Non-English publications or studies published before a specified date.

- Studies with incomplete or insufficient data for meaningful analysis.

Additionally, studies were scrutinized for explicit discussions on risk mitigation strategies related to orthodontic treatment in immunocompromised cancer patients. Key concerns such as periodontal infections, caries, and root resorption were assessed. If a study failed to adequately address these issues or lacked justification for orthodontic interventions in this population, it was excluded from consideration.

Data Collection Process

A structured data extraction protocol was followed to ensure consistency and accuracy in collecting information.

A standardized data extraction form was created, detailing essential study characteristics (e.g., author, publication year, study design), participant demographics (e.g., age, cancer type), orthodontic treatment specifics (e.g., duration, method), and primary outcome measures (e.g., occlusal alignment, malocclusion classification).

Two independent reviewers conducted data extraction to minimize errors and biases. Disagreements were resolved through discussion, and in cases of persistent discrepancies, a third reviewer provided a final decision. Extracted data were organized in a structured database for analysis.

Statistical Analysis

analysis was conducted to assess the influence of radiotherapy and anti-neoplastic agents on the successful completion of orthodontic treatment.

Results

Table 1 presents a synthesized overview of the studies included in this analysis without delving into specific study details. The studies were conducted across various regions and over different time periods. Dahllof et al. [19] carried out their research in Sweden with a modest sample of 10 participants, all younger than 12 years old. Of these, six were female, though no further details on the gender ratio were provided. In Poland, Mitus et al. [20] conducted a larger study with 104 participants, averaging 19.6 years in age. The study population was predominantly female, including 46 women, but additional gender distribution data were not available. Similarly, Mitus–Kenig et al. [21] performed a study in Poland with 80 participants, though the mean age was not disclosed. Among them, 17 were female, but no further demographic details were included. Another study by Mitus–Kenig et al. [22] in Poland involved 80 participants with a reported mean age of 19.3 years. This study had a majority of female participants, numbering 52, though specific gender ratios were not provided. Lastly, Neill et al. [23] conducted a study in the United States with a considerably larger sample of 381 individuals, though their mean age and gender distribution were not specified.

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Table 2 provides critical insights into the influence of cancer treatments on orthodontic outcomes, particularly concerning different malocclusions and orthodontic conditions. The included studies primarily examined patients who were either cancer survivors [19,20,22,23] or in the post-therapy phase [21]. One investigation [19] retrospectively assessed individuals over a 20-year period who had undergone bone marrow transplants for leukemia. Despite chemotherapy treatment, 60% of these children achieved optimal orthodontic results, indicating that orthodontic treatment can still be effective in this patient group. Another case-control study [20] compared orthodontic outcomes in cancer patients versus healthy individuals, specifically assessing Class I, II, and III malocclusions, with a focus on leukemia patients. Over three years, chemotherapy was shown to significantly diminish orthodontic treatment effectiveness, suggesting a negative impact on outcomes. A separate case-control study [21] examined patients with leukemia and brain tumors, comparing their orthodontic results to those of healthy participants. Over four years, the findings demonstrated that properly executed orthodontic interventions led to outcomes comparable to those in non-cancer patients. In a prospective case-control study [22], researchers assessed patients with leukemia, neuroblastoma, and non-Hodgkin's lymphoma against a healthy control group over a seven-year period. The study revealed a significant decline in quality of life before orthodontic therapy began, but this was notably improved following treatment, suggesting that post-treatment quality of life was similar to that of the control group. A cross-sectional analysis [23] investigated developmental anomalies and orthodontic concerns among individuals who had received various cancer treatments. Findings showed that radiation therapy—alone or in combination with other therapies—was associated with a fivefold increased risk of root resorption and microdontia compared to chemotherapy or other treatments. Conversely, those who had undergone chemotherapy alone were nearly three times less likely to develop dental complications than patients subjected to other treatment modalities.

These findings underscore the complex interplay between cancer therapies and orthodontic outcomes. While chemotherapy-treated children can still achieve desirable orthodontic results, chemotherapy appears to hinder treatment efficacy. However, when orthodontic procedures are properly performed, cancer patients can achieve treatment outcomes similar to those of healthy individuals. Furthermore, different cancer treatments influence orthodontic complications differently, with radiation therapy leading to a greater risk of root resorption or microdontia than chemotherapy. These insights emphasize the necessity of incorporating cancer treatment history into orthodontic planning and treatment strategies to optimize results while minimizing potential complications.

A statistical evaluation was conducted to examine the extent to which radiotherapy and anti-neoplastic drugs affect the successful completion of orthodontic treatment. a statistically significant association between radiotherapy, anti-neoplastic agents, and a diminished likelihood of successful orthodontic treatment completion.

Table 1. Demographic Factors Assessed in the Included Studies

Author	Year	Sample Size (n)	Mean Age (in Years)	Sex Ratio
Dahllof et al. [19]	2001	10	<12	6 females
Mitus et al. [20]	2021	104	19.6	46 females
Mitus–Kenig et al. [21]	2015	80	Unspecified	17 females
Mitus–Kenig M et al. [22]	2020	80	19.3	52 females
Neill et al. [23]	2015	381	Unspecified	Unspecified

Table 2. Oncological Variables and Assessments Observed in the Included Studies

Author	Protocol	Malocclusion/Orthodontic Issues Assessed	Type of Cancer Assessed	Follow-Up Period	Results Observed

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Dahllof et al. [19]	Retrospective	Developmental disturbances such as microdontia, enamel hypoplasia, and other issues such as crowding and overjet	Chronic myeloid leukaemia, Gaucher's disease, Acute myeloid leukaemia, Acute lymphoblastic leukaemia, T-cell acute lymphoblastic leukaemia, Acute myeloid leukaemia, Bruton's disease, Fanconi's anaemia	20 years (assessment period)	In 60% of the children, orthodontic treatment produced ideal results despite the administration of chemotherapy.
Mitus et al. [20]	Case-control (52 cancer patients and 52 healthy controls	Class I, II, and III malocclusions	Leukaemia (majority)	3 years	Chemotherapy significantly reduced efficacy of orthodontic treatment administered.
Mitus–Kenig et al. [21]	Case-control (40 cancer patients and 40 healthy controls)	Class I, II, and III malocclusions	Leukaemia and brain tumours	4 years (assessment period)	Oncological patients' treatment outcomes following a properly executed orthodontic procedure did not differ from those of healthy controls.
Mitus–Kenig M et al. [22]	Prospective case-control (40 cancer patients and 40 healthy controls)	Class I, II, and III malocclusions	Leukaemia, neuroblastoma andnon-Hodgkin's lymphoma	7 years (assessment period)	In the group of cancer patients, there was a significant decline in quality of life prior to the start of orthodontic therapy and a significant improvement after treatment,

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					showing that the outcomes of orthodontic treatment for cancer survivors were the same as those for healthy controls.
Neill et al. [23]	Cross-sectional	Developmental disturbances such as microdontia, enamel hypoplasia, and other issues such as crowding and overjet	Unspecified	Unspecified	Radiation therapy alone or in combination with any other form of treatment was five times more likely to result in root resorption or microdontia than chemotherapy or any other form of treatment. Patients who had only received chemotherapy were almost three times more likely to have no dental complications than patients who received any other form of treatment.

Discussion

This review offers valuable insights into the interplay between cancer therapies and orthodontic treatment results. The analysis suggests that orthodontic procedures can still be successful in children receiving chemotherapy, with 60% achieving optimal outcomes. Nevertheless, chemotherapy appears to hinder the effectiveness of orthodontic treatment for certain dental misalignments. Additionally, the type of oncological intervention significantly influences dental health, with radiation therapy increasing the chances of root resorption and microdontia more than chemotherapy. These findings underscore the necessity for orthodontists to consider cancer therapies when formulating treatment strategies to maximize results and minimize potential complications. A key strength of this study is its comprehensive evaluation, utilizing a forest plot to assess the influence of radiotherapy and anti-neoplastic medications on orthodontic success.

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The statistical analysis revealed a significant link between these therapies and a reduced likelihood of successful orthodontic completion. Heterogeneity assessments indicated notable variability across studies, pointing to differences in methodologies and patient demographics. The overall effect test further validated the strong correlation between radiotherapy, anti-neoplastic drugs, and decreased orthodontic success rates.

Orthodontists frequently encounter difficulties when managing patients with systemic conditions that affect dental structures [24]. These challenges arise due to the intricate relationship between the underlying disease, its treatment, and orthodontic goals [25]. Effective management requires a thorough evaluation of the patient's medical history and close collaboration with healthcare providers to ensure safe orthodontic care. Adjustments to treatment timing and duration may be necessary depending on the nature of the systemic illness and its therapies [26]. Complications such as mucositis and impaired wound healing require coordinated care with medical professionals [27]. Furthermore, medications prescribed for systemic diseases may interact with orthodontic interventions, necessitating careful consideration. Maintaining oral hygiene can be difficult for immunocompromised patients or those with physical limitations, requiring enhanced support from orthodontic specialists [28]. A multidisciplinary approach is essential to synchronize treatment objectives and mitigate potential risks [29]. Addressing the psychological and emotional burden associated with systemic illnesses is also crucial to providing holistic patient care throughout orthodontic treatment [30].

A significant concern in contemporary orthodontics is ensuring long-term stability following treatment. Research indicates that only 7.1% of cases demonstrate absolute stability between four and ten years post-treatment, while 68.6% exhibit relative stability [31]. Overbite and lower anterior segment alignment were identified as the least stable occlusal features. Another study [32] explored factors contributing to relapse after orthodontic therapy, highlighting periodontal and gingival conditions, occlusal variations, soft tissue influences, dentition limitations, and physiological relapse as key determinants. Additionally, a separate investigation [33] underscored the role of mandibular muscles in maintaining occlusal stability over time. Literature indicates that most cancer survivors experience at least one dental anomaly, including misaligned dentition, shortened roots, altered growth patterns, missing teeth, delayed exfoliation of deciduous teeth, microdontia, and enamel hypoplasia [23,34,35]. Chemotherapy has been linked to early apexification, inhibited root development, tooth discoloration, compromised oral hygiene, increased caries risk, oral lesions, and reduced salivary flow [34]. Both chemotherapy and radiotherapy affect crown and root formation, with root anomalies being more prevalent [35]. Impaired root elongation was the most frequently observed defect, whereas microdontia was the most common crown abnormality [35]. Because modern oncology often employs both chemotherapy and radiotherapy, distinguishing the precise odontogenic effects of each treatment remains challenging [35,36,37].

The influence of cancer therapies on orthodontic outcomes highlights the importance of individualized treatment strategies. A substantial proportion of pediatric patients undergoing chemotherapy can still achieve favorable orthodontic outcomes, demonstrating that such treatments remain viable in this population. However, chemotherapy may reduce orthodontic efficacy in certain cases, indicating potential adverse effects on treatment success. When orthodontic protocols are executed correctly, outcomes for cancer patients can be comparable to those of healthy individuals, emphasizing the need for precise planning and execution in orthodontic interventions. Additionally, quality of life, which may be significantly diminished before orthodontic therapy in cancer patients, has been observed to improve post-treatment, underscoring the potential benefits of orthodontic care for cancer survivors. The type of oncological therapy plays a critical role in determining dental complications. Compared to chemotherapy, radiation therapy—alone or in combination with other treatments—poses a greater risk for root resorption and microdontia. Conversely, chemotherapy alone is less likely to cause significant dental anomalies. Statistical evaluations further affirm the impact of cancer treatments, particularly radiotherapy and anti-neoplastic drugs, on orthodontic treatment outcomes. Both analyses indicate a notable association between these therapies and a decreased success rate in orthodontic procedures. These findings highlight the necessity of integrating oncological considerations into orthodontic planning and management to improve patient outcomes while minimizing adverse effects.

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Conclusions

This review underscores that orthodontic treatments remain effective in children receiving chemotherapy, though success rates may decline in older individuals. Nevertheless, properly executed orthodontic procedures can yield comparable results between cancer patients and those without a cancer history. The type of cancer therapy also significantly impacts dental health, with radiation therapy posing a greater risk of complications compared to chemotherapy. The findings emphasize the importance of incorporating oncological treatment history into orthodontic planning and decision-making to optimize patient care and reduce risks. Future research with larger sample sizes and prospective methodologies is essential to strengthen the current evidence base and account for potential confounders.

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